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much higher than in walking, this is surprising. On the other hand, in the walking experiments there was, as is customary with trained walkers, considerable arm motion which was absent in the running experiments. Basal experiments made while the subject was standing still but swinging the arms in essentially the same amplitude and rhythm as when walking showed a great increase in the resting metabolism. The use of this base line reduces the progression constant for walking to 0.780 gram-calorie with an average speed of 144 meters per minute. This debatable procedure seems to emphasize the fact that for the most economical transport of the body, with or without superimposed load, some type of gait which reduces to a minimum the elevation of the body and the extraneous arm motion is most desirable.

The details of this research are reported in Publication No. 231 of the Carnegie Institution of Washington.

THE PHYSIOLOGY OF THE NEW-BORN INFANT

By Francis G. Benedict and Fritz B. Talbot

NUTRITION LABORATORY, CARNEGIE INSTITUTION OF WASHINGTON

Presented to the Academy, November 2, 1915

The physiology of the first week of life is of especial importance owing to the unique position of civilized woman who, alone of all mammals, is usually for several days so completely exhausted by labor as to make her existence and even that of her child absolutely dependent upon the ministrations of others. The insufficiency of the breast secretion, the loss in weight of the infant, which almost invariably occurs, and the too frequent but rarely needed complete substitution of bottle feeding for breast feeding make a study of the actual needs of the new-born infant of unusual interest.

In a research carried out by the Nutrition Laboratory, in which a respiration chamber was used, measurements were made of the carbon-dioxide output and the oxygen intake, and records were secured of the pulse-rate, respiration-rate, and body-temperature of 105 new-born infants. The observations often began before the infant was 1 hour old, the child being placed in the respiration chamber as soon as it had been bathed and dressed. The metabolism was then studied, frequently in 1-hour periods, for several consecutive hours. The primary object of the research was to determine the basal minimum metabolism of the infant with special reference to sex, weight, age, and length.

From the data obtained in these observations, the respiratory quotients were computed which indicated the nature of the principal substance burned in the body, i.e., fat or carbohydrate. A critical study of these respiratory quotients shows that the new-born infant was not supplied with a superfluous amount of body carbohydrate to burn during the period of insufficient breast secretion. Indeed, the predominance of fat combustion suggests the possible necessity of supplemental feeding of carbohydrates.

Select periods of muscular repose were obtained in the majority of cases which supplied data for computing the basal metabolism or minimum heat-production. This minimum heat-production, computed on the 24-hour basis, ranged from 95 to 193 calories, but as the body-weight likewise varied, the values per kilogram of body-weight were also computed. These ranged from 32 to 52 calories per kilogram of body-weight per 24 hours. Even on the basis of per square meter of body-surface, supposedly the best basis for comparison, the values ranged from 459 to 732 calories per square meter of body surface per 24 hours.

Of the numerous comparisons made none showed sufficient regularity even to suggest a physiological law, until the factors of age and length were considered. On the basis of age the figures showed that frequently the lowest as well as the highest values occurred during the first 24 hours of life and it was clear that there were profound disturbances of the heat-regulating mechanism during this period. After the first day considerable regularity appeared in the results. When length was also considered as a variant, all infants between $1\frac{1}{2}$ and 6 days of age, 48 in number, showed that the heat-production per square meter of body-surface per 24 hours per centimeter of length was remarkably constant. The values computed on this basis rarely varied more than ± 6% from the average value of 12.65 calories, thus establishing a physiological constant for new-born infants.

The increase in the metabolism due to severe muscular exercise, such as lusty crying, averaged 65% for all infants but actually exceeded 100% in 10 instances, with a maximum increase in one case of 211%. As an evidence of the possible increase above basal metabolism in a normal, healthy, new-born infant this is worthy of special note.

The pulse-rate showed average values as follows for the first eight days: 112, 114, 116, 116, 116, 122, 119, and 126 beats per minute. A profound disturbance of the rectal temperature accompanied the bath following birth and this probably explains the great fluctuations in the heat values for the first day. Indeed, it is suggested that the bath be deferred for a day to permit the deficient heat-regulating mechanism a longer period of adjustment.

The probable daily maintenance requirement of energy for a new-born infant, with the usual periods of activity, asleep, and awake, is estimated to be approximately 62 calories per kilogram of body-weight per 24 hours. This takes no account of the requirement for growth, which may be neglected in considering the energy requirement for the first week of life. The results of the research give opportunity for suggestions as to supplemental feeding and methods of conserving energy.

A detailed report of the investigation, together with a complete translation of the interesting article on the respiratory exchange of infants, published by Hasselbalch in 1904, is given in Publication No. 233 of the Carnegie Institution of Washington.

A COMPARISON OF METHODS FOR DETERMINING THE RESPIRATORY EXCHANGE OF MAN

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The principal methods of determining the respiratory exchange of man in short periods require the use either of a chamber in which the subject is confined or breathing appliances which are attached to the nose or the mouth or, as in the case of a mask, to the face. Apparatus with breathing appliances are of two classes. In one the subject breathes into and out of a closed current of air driven by a positive blower, the products of respiration being absorbed and oxygen being admitted. In the other type of apparatus valves are used to separate the currents of inspired and expired air and the latter is either measured by a meter or collected in a bag or a spirometer, a sample being taken and analyzed by means of a suitable gas-analysis apparatus.

Thus far no adequate comparison of these different types of apparatus has been made, the only attempt at such comparison being the compilation of results obtained with various respiration apparatus to show that these apparatus measured accurately the respiratory exchange. It therefore seemed desirable to compare the several types of apparatus for determining the respiratory exchange, with men as subjects and with as nearly identical conditions as possible.

The apparatus employed in this investigation were the following: Bed respiration calorimeter (chamber type with closed circuit); two forms of the Benedict universal respiration apparatus, i.e., tension-equalizer unit and spirometer unit (apparatus with breathing appliance, closed circuit type); Zuntz-Geppert apparatus (valves with meter and gas-analysis apparatus); Tissot apparatus (valves with an automatically counterpoised spirometer); Douglas apparatus (valves with rubber-lined cloth